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Student Centered Education

Commentary: Why Abandoning Undergraduate Laboratories Is Not an Option

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Laboratory exercises (labs) are sometimes regarded as dispensable in BMB education for various reasons including a combination of increased class costs and small budget allocations, pressing demands for more time to lecture to fit in new BMB discoveries within constant time span of courses, and the fact that labs' look less powerful for illustrating BMB content as state-of-the-art research technologies gain complexity and sophistication. Virtual environments are also in the equation: available examples from other sciences—pathology, for example—which are taught with virtual instead of real labs, question what justifies the allocation of facilities, technicians, and faculty to BMB labs. Finally and equally important, are the conclusions that the quality of labs is often below educational standards. Recent reports [1, 2] emphasize the need for severe changes: from "cookbook" labs—in which students do little more than following a protocol, one step at a time with highly predictable results—to "enquiry-driven" or "project-like" labs. Dropping labs may look far more convenient than making profound reforms, which are always time consuming and, at the end of the day, will not be taken into consideration in academic faculty evaluations or promotions.

One may agree on the relevance of (some of) the above arguments. However, they disregard a quintessential aspect of laboratory exercises: the singular educational value for students or, in other words, the student-centered dimension of laboratory exercises.

Student-centered laboratory exercises are invaluable in BMB curricula because they target unique dimensions of student learning. In fact, the contribution of labs is well beyond their acknowledged role in developing the practical skills of students—designing and running experiments, making and describing observations, interpreting results, and using knowledge independently to answer questions. Student-centered labs are unique occasions to expose students to science like scientists do it—unclean, slow-paced, and open-ended—and portray, perhaps with some realism, the world of enquiry and research. They invite students to participate in the process of science as "unfinished work," something very difficult to promote in tutorials or lectures. They are also exceptional self-assessment opportunities, by confronting students with their own limitations and successes and requiring timely actions (for example, to proceed with an experiment or with an interpretation of an observation). By calling for the application of knowledge, techniques, and competences from other disciplines, labs reveal interfaces which discipline textbooks do not give away. Last but not least, labs are invaluable opportunities for nurturing student interest in BMB—science student imaginaries are populated with scientists, laboratories, and experiments.

Student-centered laboratory exercises must focus on the needs of the student, rather than on the practicalities of traditions of departments or institutions. They must confer on students an adequate degree and sense of autonomy to participate in experimentation of BMB. This is not the case of labs that focus students' attention mostly on following a certain experimental protocol (cookbook labs) or that allow only a few students to do hands-on work while most sit quietly and watch instructors or colleagues doing work. Instead, student-centered labs, to a certain level, must require input or decision from students to design the experiments and therefore might originate singular results, demand active discussions and collaboration between students and originate results, not all easily anticipated, that lead students to pose questions or test hypotheses.

The design of feasible student-centered labs starts with the comprehensive definition of course outcomes—knowledge, competences, and behaviors—that students should master at the end. Outcome lists are tools to make explicit what students should take away from courses and, therefore, what assessments should focus on. They are more easily developed within multidisciplinary groups of faculty by building consensus. The process can be greatly facilitated by consulting available consensus documents [1, 3, 4]. The second step is the definition of the set of experimental skills and techniques that students should practice and the corresponding level of proficiency at which they are expected to perform: for example, it may be reasonable that first-year

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students of an introductory BMB course can independently perform a spectrophotometric measurement but perhaps not an SDS-PAGE. Ideally, this exercise should also be shared with colleagues (at least) from any courses that run simultaneously. Once again, existing resources [4, 5] make excellent starting materials. The third step crosses the bridge to reality and, of what is included on the lists, defines what is feasible to achieve under local circumstances in one course and what needs to be shared by other courses. Finally, open-ended projects to offer to students should be devised. These could be progressive, for example, moving from less student participation to classes where students independently plan and run experiments. It is important to create time for students to make mistakes, get appropriate feedback, and learn how to think inquisitively. Also, there should be opportunities for all students to repeat what is considered priority.

The development of the ability to do science is a self-paced process. Some students will learn faster than others. Labs should provide a fair learning opportunity for every student. Therefore, student-centered labs demand long term, preferentially interdisciplinary planning, to target the development of student scientific competences. They also require formative feedback and valid and reliable assessments to base decisions of individual level of competency.

Fitting the above ideas in a one semester course may look like Mission impossible. There does not seem to be enough time. However, if one sits back, one finds that current labs—protocols and assessments—do not always focus on what is essential. Furthermore, labs can make use of alternative tools, for example, e-learning. Virtual learning environments may be even better than labs for the purpose of having students visualize equipment or time-consuming techniques (for example, SDS-PAGE), because they can be watched 24 × 7, as many times and paused as many times as needed. Visualizing online materials preclass frees time for other exercises.

In summary, laboratory exercises are indispensable in BMB curricula, as long as they are designed with the students in mind. It is our job to turn laboratory classes into student-centered exercises and to contribute to their development and dissemination.

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